ED-184F

FILE COPY

DEPARTMENT OF THE ARMY
CORPS OF ENGINEERS

MAGNETIC DEMOLITION DEVICE

"CLAM"

Project FB 79-b

7 February 1958

US ARMY ENGINEER RESEARCH AND DEVELOPMENT LABORATORIES

FORT BELVOIR, VIRGINIA

ARMY—FORT BELVOIR, VA.

U. S. ARMY ENGINEER RESEARCH AND DEVELOPMENT LABORATORIES
CORPS OF ENGINEERS

MAGNETIC DEMOLITION DEVICE

"CLAM"

Project FB 79-b

7 February 1958

Prepared by

Richard J. Robbins
Demolitions and Fortifications Branch
Military Engineering Department
U. S. Army Engineer Research and Development Laboratories
Corps of Engineers
Fort Belvoir, Virginia

TABLE OF CONTENTS

INDEX OF PHOTOGRAPHS

INDEX OF PHOTOGRAPHS (Cont)

I SUMMARY

A magnetic demolition device, nicknamed "clam" was delivered to this agency for evaluation testing. The limitations and effectiveness of the device were evaluated by a series of eleven tests listed below.

1. Reliability at ambient temperatures.
2. Reliability at High temperatures.
3. Reliability at Low temperatures.
4. Reliability at high temperatures with 100% humidity.
5. Reliability after being submerged in water.
6. Handling tests at high temperatures.
7. Handling tests at low temperatures.
8. Holdability test.
9. Drop test.
10. Auto Demolition
11. Steel Penetration.

The device proved to be 100% reliable under a variety of severe conditions. The tests indicated that its adaptability and effectiveness were sufficient to make this device valuable for certain military applications.

II INTRODUCTION

1. Subject. This report covers tests conducted on a plastic, magnet-equipped, explosive container, nicknamed "Clam", to determine its effectiveness, reliability, and adaptability.

Authority for conducting this test is contained in project card 8-07-10-101, and funded under Project FB 79-b.

2. Personnel. Tests were conducted under supervision of Pfc Richard J. Robbins, Project Engineer, Bernard F. Rinehart and Joe P. Roysdon. Also participating were Samuel W. Simmons, Joseph W. Latka, Thomas J. Johnson, and Jesse M. Tyson.

III INVESTIGATION

a. Description of Device. The "clam" magnetic demolition device is a small plastic box which can be filled with explosive and closed with a removable lid. Four magnets which serve to hold the device against iron or steel are positioned near the corners. The "clam" is designed to incorporate two non-electric blasting caps and two M1 delay type firing devices to initiate the explosive. It may be filled with a plastic type explosive (composition C3 or C4) at the place and time that it is employed. The plastic explosive, caps, and firing devices are not part of the device but are standard demolition materials available in supply channels.

The "clam" designed to be used in any demolition job requiring a small time delayed magnetic device such as storage tank demolition, vehicle demolition, etc., is illustrated in figures 1 and 2. The outside dimensions of the device are approximately 6" long, 2 7/8" wide and 1 1/4" deep. The dimensions do not change with the addition of explosive, caps and delay firing devices, Figure 3. Either of the firing systems will initiate the explosive, however the dual system does provide greater reliability. Only one delay detonator was used in most of the tests conducted. The cap is detonated by the flame which leaves the large end of the delay device. This flame is bent 180° from the point it enters a curved duct to the point it enters the cap. The curved duct is invisible unless the clam is sectioned, however the open ends are visible, Figure 1. The large end of the delay firing device fits into the end of the duct nearest the outside of the clam and the cap fits over a small nipple which extends from the other end. The delay firing device, the duct and the cap, when considered together are sometimes herein referred to as the "firing train."

b. Statement of Test Procedures. A test plan, which was drawn up, after receiving the requirements for the "clam" tests, was followed while running the tests, but not cronologically. Several tests were run simultaneously.

Test 1. Reliability at Ambient Temperatures

Part 1. Fifty clams were tested using one firing train, (i.e., one detonator and one cap). 20% fired low order.

Part 2. Ten clams were tested with one modification in an attempt to remedy the low order detonations occurring in part 1. The end of the cap well was cut out to permit direct contact of the cap with the explosive. The ten modified clams were also tested using one firing train with one low order detonation.

Part 3. Ten clams were tested with a second modification. The end of the cap well and 3/8" of the bottom of the cap well were removed. One firing train was used and low order detonations continued.

Part 4. Twenty-five clams were tested with a third modification. The end of the cap well and 1/2" of the bottom were removed. The cap well was half filled with C4 so that it surrounded the cap with no low order detonations.

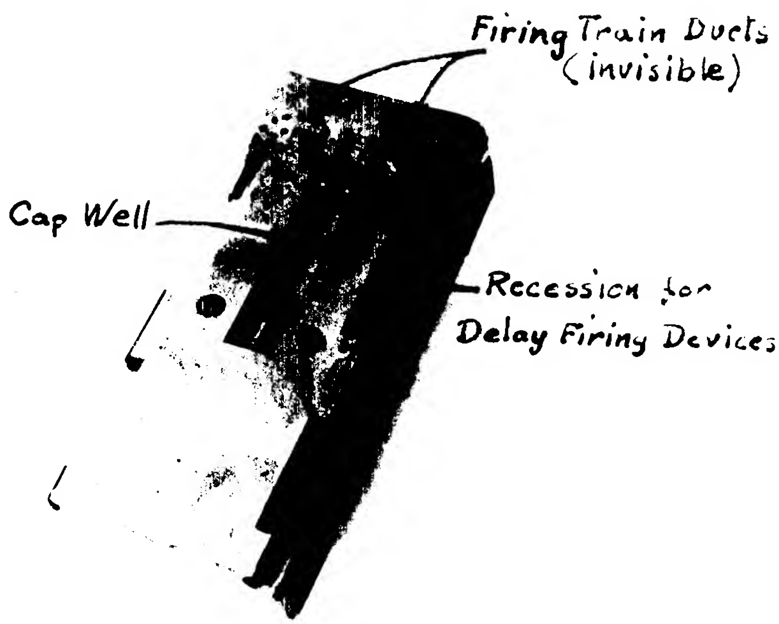

Fig. 1 "Clam" viewed from top.

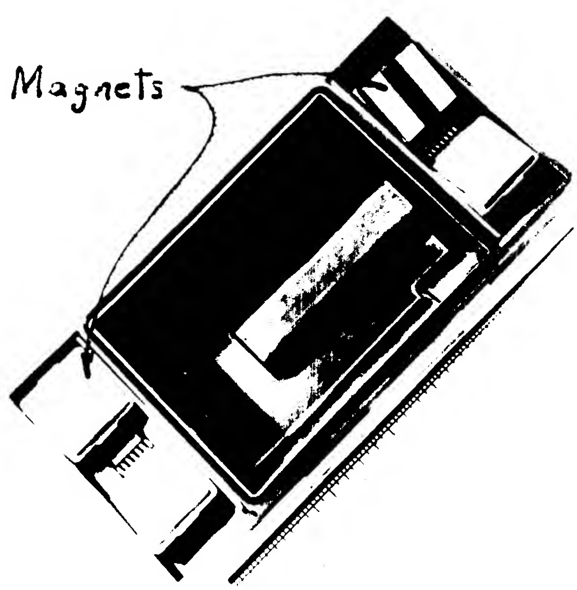

Fig. 2 "Clam" viewed from bottom (with lid removed)

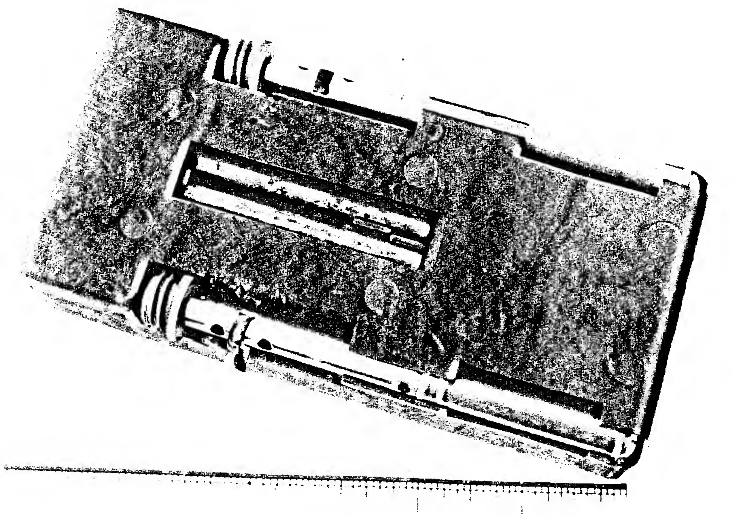

Fig. 3 "Clam" armed, ready for use.

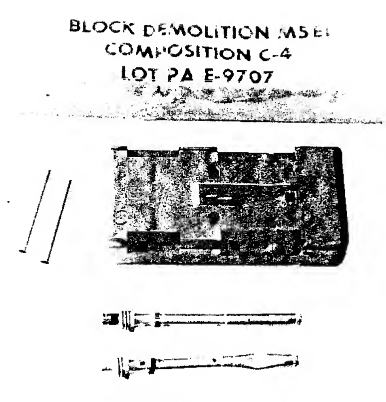

Fig. 4 "Clam" and demolition materials necessary for loading and arming.

Part 5. It was determined that the modifications made in part 4 were undesirable and should be avoided if at all possible. In actual operations two complete firing trains would be employed, the second cap should act as a booster and eliminate the low order detonations. Four hundred clams were tested with no modification. One firing train was used, with two caps and one delay firing device. Results are tabulated in D.5.

Part 6. Ten "clams" were loaded with 120 grams of C4. The density of the explosive was lowered from 1.38 g/cc to .81 g/cc. The "clams" were tested with two caps and one delay detonator. All fired high order.

Part 7. Ten "clams" were loaded at ordinary density, but with an air gap around the sides of the capwell. The clams were tested with two caps and one detonator. No failures occurred.

Test 2. Reliability at High Temperatures

Part 1. Two "clams" were loaded with C4, heated to 120°F and allowed to cool at room temperature. The inside temperature was recorded so as to determine the rate of cooling for temperature control in Part 2.

Part 2. One hundred and five "clams" were tested at 120°F loaded with C4, two caps and one delay firing device.

Test 3. Reliability at Low Temperatures

Part 1. Two "clams" were loaded with C4, cooled to -35°F and allowed to warm up to air temperature. The inside temperature was recorded to determine the rate of warming for temperature control in Part 2.

Part 2. Eighty-nine "clams" were tested at -30°F. Two caps and one delay firing device were used. No failures occurred.

Test 4. Holdability

"Clams" were tested for adhesion to various parts of a jeep while traveling over rough terrain.

Test 5. Drop Damage

"Clams" loaded with simulant explosive, inert caps, and live firing devices were dropped from various heights on both gravel and concrete to determine the safe drop limits.

Test 6. Handling at High Temperatures

Five "clams" were tested at 120°F with both C3 and C4. Time for loading the 5 "clams" was recorded as well as description of handling the explosives and arming the "clams" at an extremely high work temperature.

Test 7. Handling at Low Temperatures

Five "clams" were used in this test at -30°F. Handling conditions, loading time, descriptions of arming, and some suggestions for design improvement were recorded.

Test 8. Reliability Under Conditions of High Temperature and 100% Humidity

Ten "clams" were loaded, armed, heated to 120°F and 100% humidity and tested.

Test 9. Reliability After Being Submerged in Water

Part 1. One "clam" was submerged under 6" head of water for 48 hours and was examined for internal dryness.

Part 2. One "clam" was loaded, armed and immersed under 6" of water for 48 hours and tested. Seventy "clams" were loaded and armed. Ten "clams" were submerged in 6 inches of water for 24 hours; ten submerged for 18 hours; ten submerged for 16 hours; ten submerged for 14 hours; twenty submerged for 12 hours and ten submerged for 6 hours. All "clams" were test fired immediately after removal from the water.

Test 10. Vehicle Demolition

Several "clams" were fired at selected points on a Chevrolet Station Wagon in order to determine the relative effectiveness of placing the "clams" at various points on the vehicle.

Test 11. Steel Penetration

Sixty "clams" were tested for penetration of mild steel plate on various thicknesses of mild steel plate and using various densities of loading. Some "clams" were tested for effectiveness without the lids on the explosive cavity between the explosive and the steel plate as compared to those with the lids on.

c. Description of Test Methods.

Test 1. Reliability at Ambient Temperatures

Part 1. Fifty "clams" were hand packed with C4. With a little practice one can load a "clam" with almost 1/2 lb of C4 and achieve good density. The "clam" loading was standardized at 205 grams throughout the test except where special specific gravities were requested.

Although the device was designed to incorporate two caps and two delay firing devices, (that is two firing trains), it was decided, since the delay firing devices would seldom or never fire simultaneously, that the use of one firing train would be sufficient for the test. Therefore, the first fifty "clams" were armed with one cap and one firing device only.

As each "clam" was fired, the shot number and a statement of whether the "clam" detonated high or low order were recorded. Explanations and descriptions were recorded where necessary. Temperature and functioning time of each delay device were also recorded. These data have been condensed into Table I of the appendix. From the table one can compare the results of the delay detonators used in the test with the predicted functioning times as shown in Table VI of TM 9-1946, Demolition Materials, and Table VII, FM 5-25, Explosives and Demolitions.

Ten of the first fifty "clams" tested fired low order.

Part 2. After finding a large percentof low order detonations in the first 50 "clams" tested, it was decided that the plastic between the cap and the C4 might be just enough of a shield to decrease the effectiveness of the cap to a point of unreliability. The next ten "clams" were modified to determine how much effect the plastic of the cap well had in shielding the explosive from the blast of the cap. The end of the cap well was cut out so that the end of the cap was in direct contact with the explosive, Figure 5. Ten "clams" with this modification were tested using one firing train, with one of the ten firing low order.

Part 3. A second modification was applied to another group of ten "clams". The ends of the cap well and 3/8" of the bottom of the cap well were removed. This modification was made so that even more explosive would be in direct contact with the cap, Figure 6. The ten "clams" were also tested using one firing train. Three fired low order.

Part 4. As a result of a high percent of low order detonations, a third modification was made on twenty-five "clams". The end of the cap well, and approximately 1/2" of the bottom of the cap well were cut out. The cap well was half filled with explosive after the cap was put in place so that the cap was surrounded by explosive, Fig. 7. The twenty-five "clams" were tested with one firing train. All fired high order.

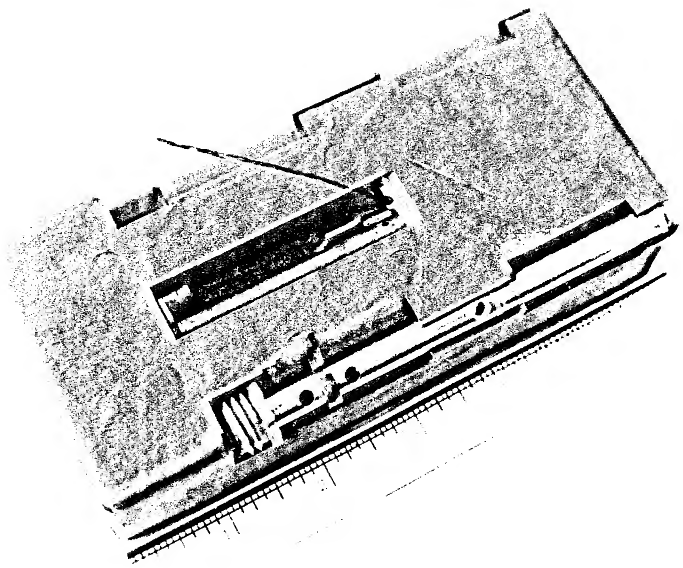

Fig. 5 Armed "clam" with end of cap well cut out.

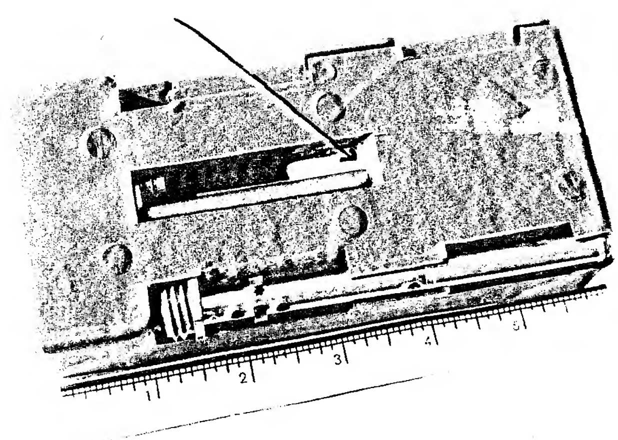

Fig. 6 Armed "clam" with the end and part of the bottom of the cap well cut out.

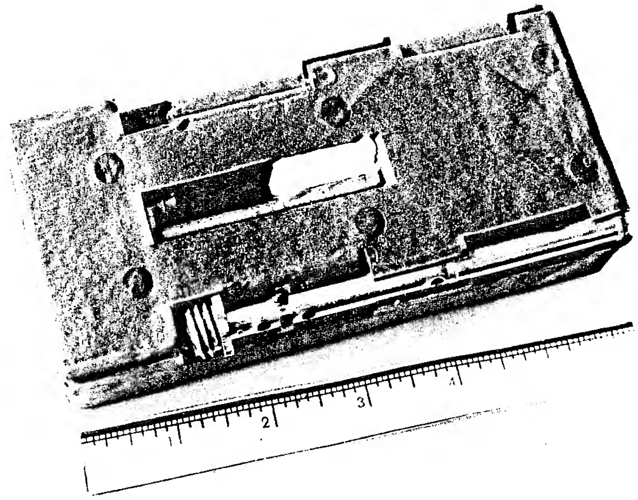

Fig. 7 "Clam" with the end and part of the bottom of cap well cut out and C4 packed around cap.

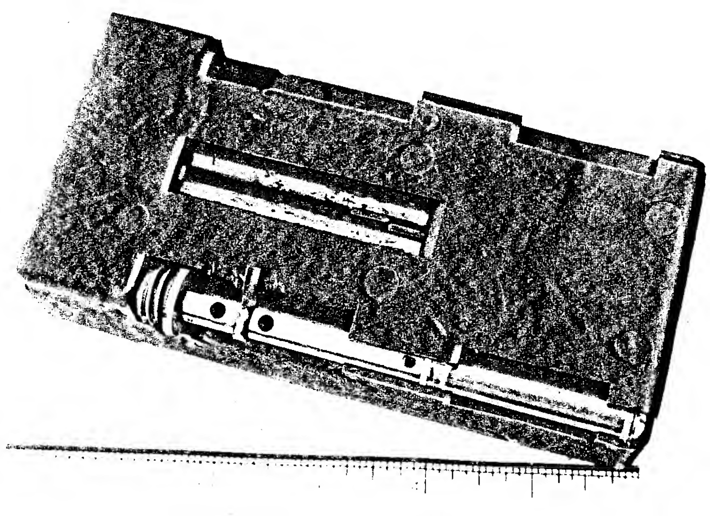

Fig. 8 "Clam" armed with two caps and one delay firing device. This is the arming set-up used throughout most of the tests.

Part 5. It was felt that using two caps to initiate the explosive would improve the reliability to an acceptable point. The two caps would not be detonated at the same instant, but the second cap would serve as a booster when initiated by the cap in the complete firing train. Four hundred "clams" were loaded, armed and tested using one firing train and two caps, Fig. 8. No modification was made to these "clams" and all fired with high-order detonations.

Part 6. A "clam" loaded with 205 grams of C4 has an explosive density of 1.38 g/cc. If the "clams" were hurriedly loaded with explosive by an inexperienced person, poorer compaction and lower density would result. It was suspected that a lower density might affect the reliability of the "clams". In order to determine this effect an exagerated condition was set up. Ten "clams" were carefully loaded with C4 in an effort to attain a very low density by shredding the C4, resulting in the "clams" being filled with 120 grams of C4 at a density of .81 g/cc. These "clams" were tested with one firing train and two caps and all ten fired high-order.

Part 7. At low temperatures an explosive normally looses some of its plasticity and unless considerable care is exercised in loading "clams" at these temperatures, an air gap between the explosive and sides of the cap well will result. In order to simulate such a condition ten "clams" were loaded purposefully with an air gap around the cap well. This was accomplished by loading the "clams" with 205 g of C4, turning them over and allowing the explosive to fall out of the box. The explosive was cut away from around the cap well by making a 45° bevel cut. The explosive was then carefully replaced in the "clams", thus providing air gaps of equal size and the location duplicated in each "clam". Ten "clams" were loaded and tested in this manner with all high-order detonations resulting.

Test 2. Reliability at High Temperatures

Part 1. Two "clams" were tested to find their rate of cooling after being heated to 120°F when exposed to room temperature. The test was conducted to determine how much over heating was required and the allowable set-up time in the reliability part of the test. The "clams" were loaded with C4 and a thermometer was imbeded in the center of the explosive. The "clams" were then placed in a preheated oven at 125°F andheated for one hour. They were then brought out into room temperature (81°F) and allowed to cool, Fig. 9. The rate of cooling was recorded.

Part 2. One hundred and five "clams" were loaded, and armed with two caps and one delay firing device. At 120°F the delay firing devices should fire in one and a half minutes and as a safety measure it was decided that some other method of initiating the delay firing devices should be used. An electric cap was taped to the corner of the "clam" just over the chemical end of the firing device so that the blast of the electric cap would sever

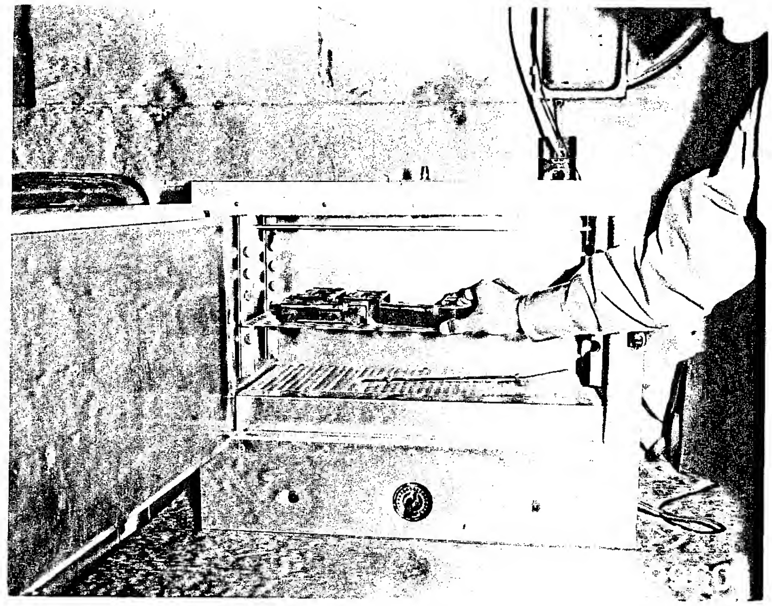

Fig. 9 Removing "clam" from oven.

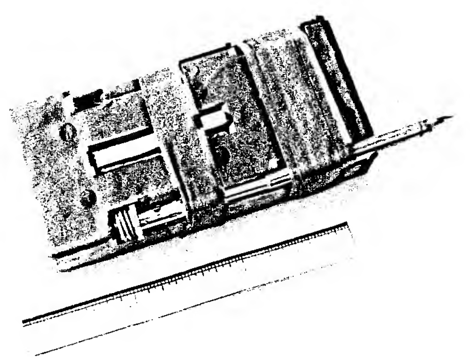

Fig. 10 Electric cap taped onto the end of delay firing device and dowel taped onto the non-electric caps to hold them in place.

the wire in the firing device and thereby release the firing pin. The remainder of the firing train then functions in a normal manner. The blast of the electric cap caused enough shock to kick the non-electric caps in the firing train partly out of their cap well causing some low-order detonations. The non-electric caps in the firing train were then secured in position by placing a small wooden dowel on top of them and taping it in place. Complete control was thus obtained in the firing of the "clams", Fig. 10.

One hundred "clams" were then armed with the modifications described above, heated to 125°F and tested. All "clams" fired high-order.

Test 3. Reliability at Low Temperatures

Part 1. Two loaded "clams" were tested to find their warming rate after being cooled to -30°F when exposed at room temperature. This portion of the test was run in the same manner as Part 1 of Test 2. The "clams" were cooled at -35°F for one hour and then exposed at room temperature and the rate of warming recorded.

Part 2. Eighty-nine "clams" were loaded and armed with the modifications described in Part 2 of Test 2. The non-electric caps in the firing train were taped in their wells and an electric cap was used to initiate the delay firing device. Forty "clams" were cooled in the cold hold to -30°F and tested. Forty-nine "clams" were soaked in the cold hold for 96 hours at -20°F then placed in a cork lined box with dry ice which brought their temperature down to -30°F. The last twenty "clams" in this test were allowed to remain in the box with the dry ice until they had reached temperatures ranging from -32°F to -50°F. The individual temperatures were recorded before firing. All "clams" fired with high-order detonations.

Test 4. Holdability

Ten "clams" were loaded with C4 simulant and each was armed with two inert caps and two live delay firing devices. The "clams" were placed on various parts of a jeep and the jeep was driven over very rough terrain. One position selected was the bottom of the gasoline tank. The tank was smooth, painted and horizontal. Another position selected was the bottom of the oil pan. This surface was similar to the gas tank on a commercial automobile. A third "clam" was placed on the side of the engine block with a vertical cast iron surface. "Clams" were placed on the top and bottom of the differential housing and on the axle housing. "Clams" were tested on vertical surfaces of different degrees of smoothness. A "clam" was placed on the wheel of a pickup, under the hub caps to determine if it would be thrown off by the spin. For results see Test 4 of Section III d.

Test 5. Drop Test

"Clams" were loaded with C4 simulant, inert caps and live delay firing devices. The prepared "clams" were then dropped on concrete and coarse gravel

from heights varying from 2 ft to 10 ft in 2 ft increments. Two "clams" were tested on concrete and two on gravel at each height. The "clams" were checked to see whether lids remained secure, for damage to "clams", and the caps and delay firing devices were checked for damage and activation.

Test 6. Handling at High Temperatures

Five "clams", two and a half pounds of C4, 2 1/2 lbs of C3, ten inert caps and ten de-activated delay firing devices were placed in the temperature test vault at room temperature with thermocouples embedded in the center of the blocks of explosive.

It was desired to conduct the tests at 120°F and in order to speed up the heating process, room temperature was maintained at 145° until the center of the explosive reached 120°. Room temperature was then reduced to 120° and maintained there for the tests. Wet bulb and dry bulb temperatures were recorded along with the center of the explosive temperature, by a continuous strip recording machine, Fig. 11. During the test the total time for loading and arming five "clams", and the separate times for various loading operation were recorded. Notes were made on the ease or difficulties in handling explosives, description of arming "clams", along with objectionable features and/or improvements to the design of the "clam".

Test 7. Handling at Low Temperatures

Five "clams", 2 1/2 lbs of C4, 2 1/2 lbs of C3, ten inert caps and ten deactivated delay firing devices were placed in the temperature test vault at room temperature with thermocouples embedded in the center of the blocks of explosive. The three temperatures (wet bulb, dry bulb, and center of explosive) were picked up by the three thermocouples and recorded as in Test 6. The temperature was lowered to -55°F for three hours. By this time the center of the explosive had reached -30°F. The room temperature was allowed to warm up to -35° and the test was conducted, Fig. 12. As in Test 6, the time for loading and arming the "clams" was recorded. Notes were made on the ease or difficulties encountered in handling the explosives, description of arming along with objectionable features and/or improvements to the design of the "clam".

Test 8. Reliability at High Temperatures and 100% Humidity

Ten "clams" were loaded with 205 g of C4, armed with two caps and one delay firing device and placed in an oven at 120°F and 100% humidity for 65 hours. The "clams" were then removed and detonated electrically as in Test 2. All fired high-order.

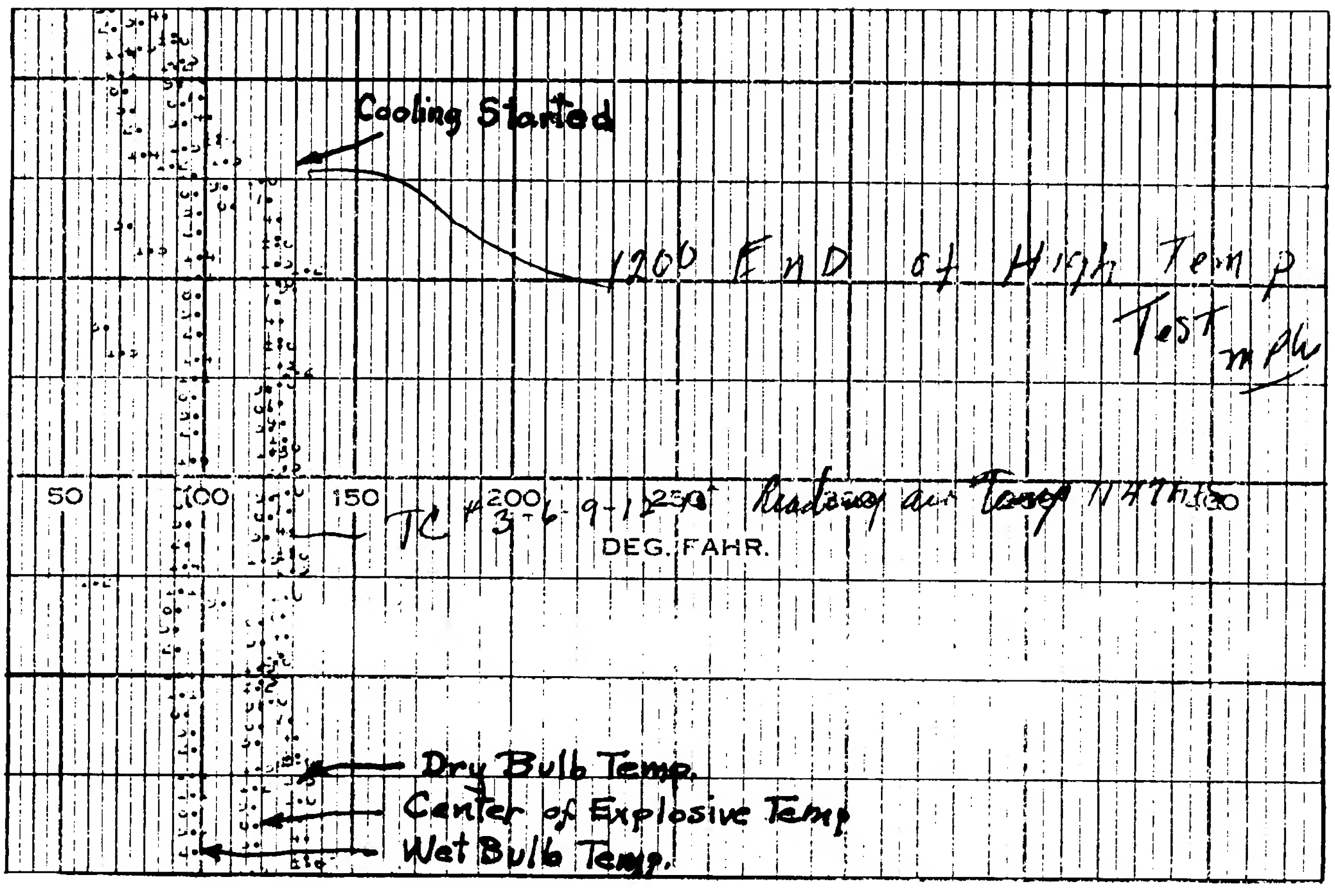

Fig. 11 Strip temperature record.

Fig. 12 Handling test at low temperatures.

Fig. 13 Water immersion test.

Test 9. Reliability After Being Submerged in Water

Part 1. One "clam" was armed with a cap and a delay firing device and placed in a water tank under a 6" head of water for 48 hours, Fig. 13. The water temperature was 68°F. The "clam" was removed and its surface dried. The cap was removed from the cap well and checked for moisture. The unit was reassembled and tested for functioning.

Part 2. One "clam" was loaded, armed as in Part 1 above and immersed in 6" of water for 48 hours. The water temperature was 70°F. The "clam" was removed and immediately tested.

Ten "clams" were loaded, armed, immersed in 6" of water at 68°F for 24 hours and tested. Ten "clams" were immersed in 6" of water at 68°F water temperature for 18 hours. Ten "clams" were immersed in 6" of water for 6 hours at 64°F temperature and tested. Ten "clams" were then immersed in 6" of water for 12 hours at 64°F and tested. The reason for the apparent unsystematic variation of time of these tests was that we were trying to get as close as possible to the amount of time that we could immerse the "clams" without a misfire, and arrive at this amount with the fewest number of shots. We next tested ten "clams" in 6" of water at 64°F for 16 hours. Ten "clams" were immersed in 6" of water for 14 hours and the last group for 12 hours. A twelve hour immersion was considered to be a maximum safe time limit.

Test 10. Auto Demolition

The purpose of this test was to find the most effective way to disable or totally destroy a vehicle. The vehicle tested was a Chevrolet Station Wagon. A "clam" was placed on the side of the engine block (an in line six cylinder engine), between the third and fourth cylinders, Fig. 14. Another "clam" was placed in the middle of the under side of the oil pan and fired, Fig. 15. A third "clam" was used to test the effect of an interior shot, by placing it on the floor of the car, directly under the driver's seat and fired. The rear of the car was jacked up off the ground and supported under the axle housings and a "clam" was placed under the rear hub cap, and the hub cap replaced, before firing, Fig. 16. The fifth "clam" was then placed on the top of the rear differential housing and fired, Fig. 17.

Test 11. Steel Penetration

The purpose of this test was to get some idea of the destructive power of the "clam", especially to determine the amount of penetration obtainable, when applied to mild steel such as that on heavy pipes and fuel tanks. The "clams" were tested for penetration against mild steel plate and both the thickness of the plate and density of explosive in the "clam" were varied. The "clams" were loaded with four different densities: 1.20, 1.38, 1.42 and 1.58, and tested against one foot square plates of 1/4", 1/2" and 3/4" thickness, and three ft by three ft plates of 7/8" thickness.

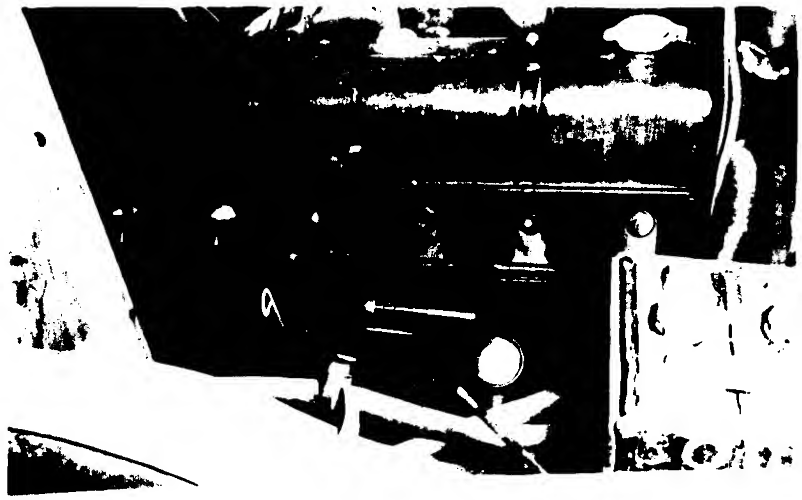

Fig. 14 "Clam" on engine block.

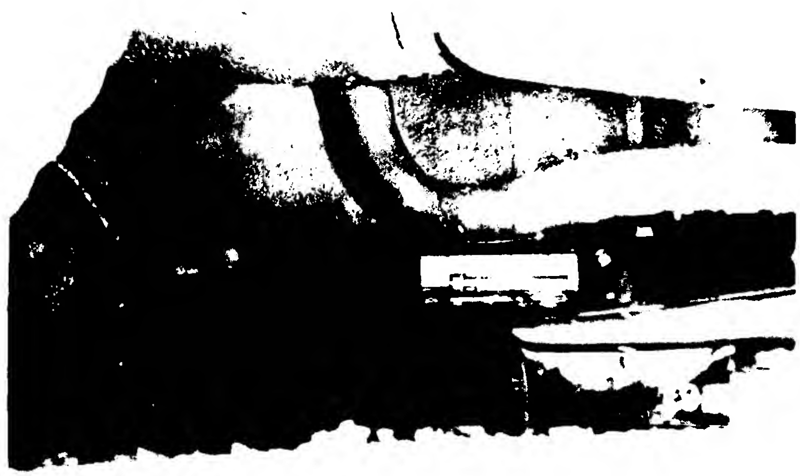

Fig. 15 "Clam" on oil pan.

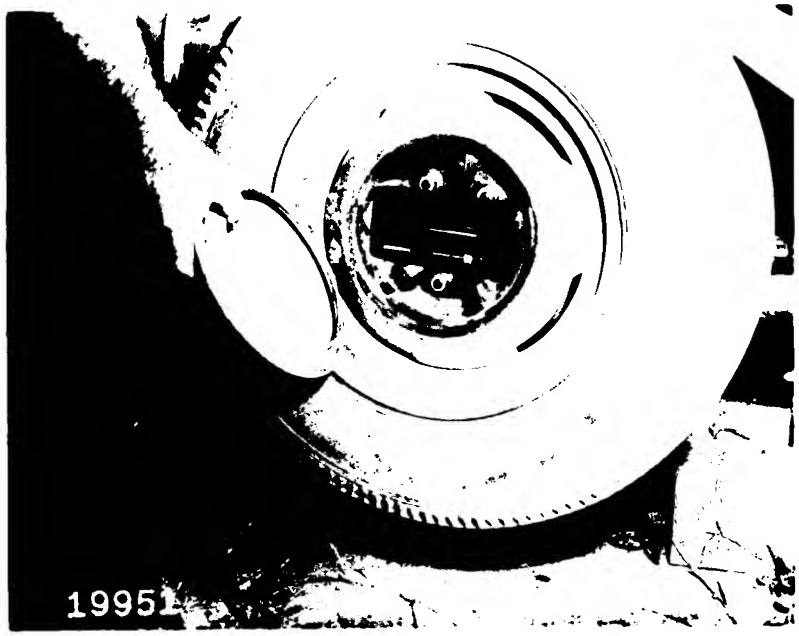

Fig. 16 "Clam" under hub cap.

Fig. 17 "Clam" on rear differential.

Declassified in Part - Sanitized Copy Approved for Release 2011/11/08 : CIA-RDP78-03639A001300110001-8

During these tests the thickness of the plate, the explosive density, penetration, spall and other measurable factors were recorded. The six different types of setups for this test are shown in Figs. 18 - 23. Fig. 22 shows a 3/4" plate taped to a 1/4" plate. Fig. 23 shows a "clam" on a curved piece of 3/8" steel. Most of the shots were of the types shown in Figs. 18 and 19.

d. Test Results

Test 1. Reliability at Ambient Temperatures

Part 1. In the first group of "clams" tested ten out of fifty fired with low-order detonations. Fig. 24 shows the recovered parts of a "clam" that fired low-order. This "clam" was damaged less than most of the others that detonated low-order with almost all of the C4 retained in the "clam".

Part 2. The clams in this group were modified by cutting the end of the cap well out. One out of the ten "clams" tested fired low-order.

Part 3. The end and 3/8" of the bottom of the capwell were removed from the ten "clams" in this group. Three low-order detonations resulted when they were fired.

Part 4. The third modification was to remove the end and 1/2" of the bottom of the capwell, put the cap in place and pack C4 around half of the cap. Twenty-five "clams" were tested and all fired high-order.

Part 5. No modification was used on this group of "clams", but two caps were used with one delay firing device. 273 "clams" were tested with all high-order detonations escept two which were initiated with #8 Atlas non-electric caps. The standard engineer special caps were used for all the other tests conducted.

Part 6. The ten "clams" loaded at low density all fired high-order.

Part 7. The ten "clams" loaded with the air gap around the cap well all detonated high order.

Test 2. Reliability at High Temperatures

Part 1. The first "clam" was heated to 125°F and allowed to cool at room temperature (81°F). In four minutes it had cooled to 120°F, and in nine minutes it cooled to 115°F. The second "clam" was heated to 124°F and six minutes after removal from the oven it cooled to 120°F. It was decided that if the "clams" were heated to 125°F we could allow the "clams" to cool for five minutes before they had cooled below 120°F. Ordinarily it took much less time than this to set up the "clams" and fire them electrically.

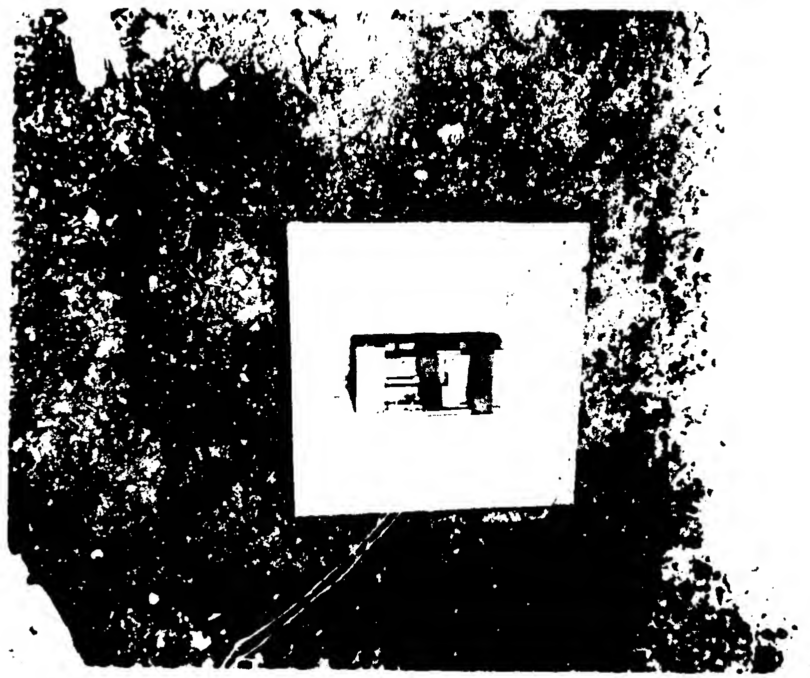

Fig. 18 Set-up with 1 sq ft mild steel plate lying on mud.

Fig. 19 Set-up with "clam" on 3 ft x 3 ft mild steel plate.

Fig. 20 Set-up with 1 ft sq mild steel plate leaning against a wall with no material behind it.

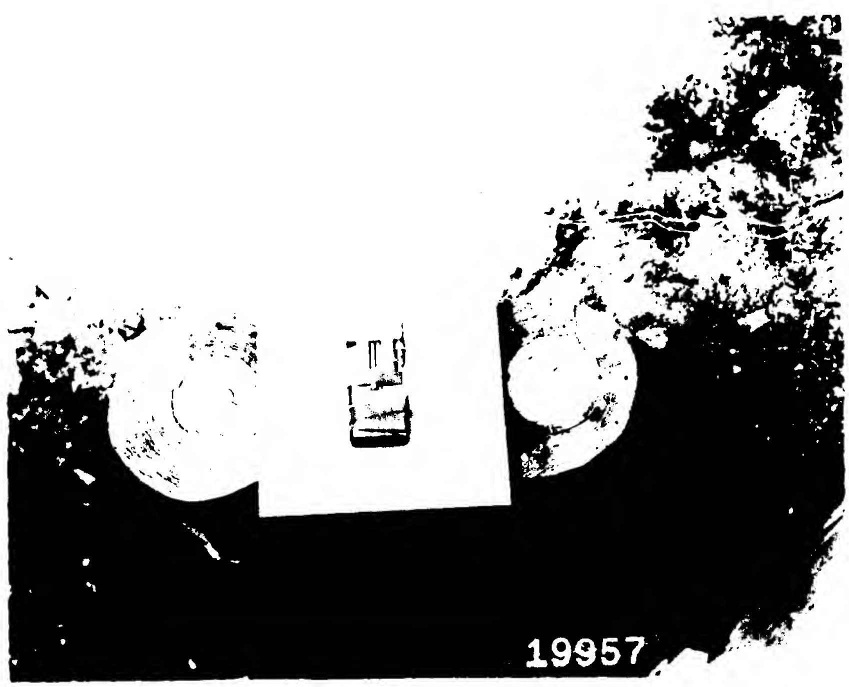

Fig. 21 One ft plate wood blocks. A 1 ft sq mild steel plate supported by wood blocks.

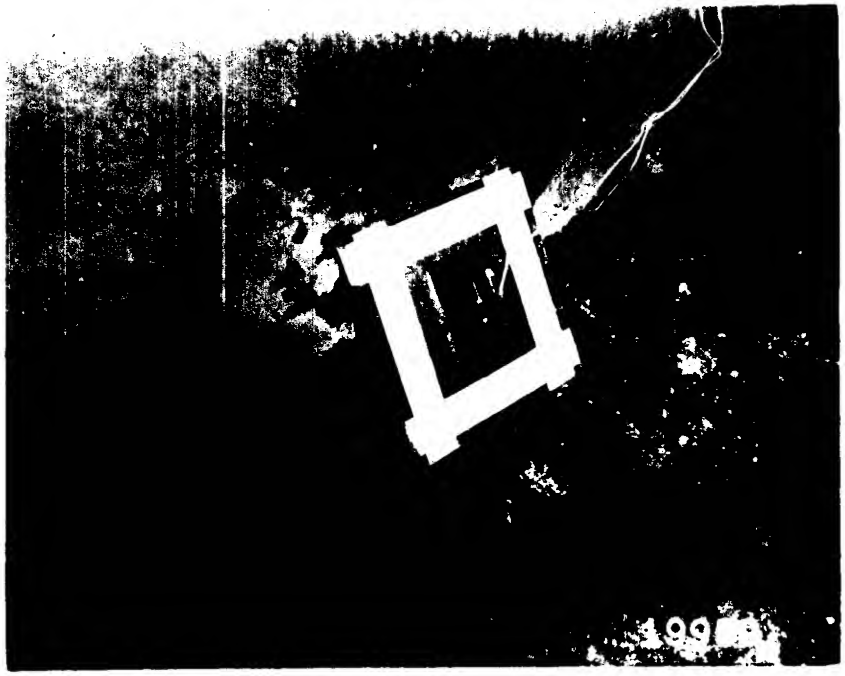

Fig. 22 Two mild steel plates taped together.

Fig. 23 Set-up on curved steel plate.

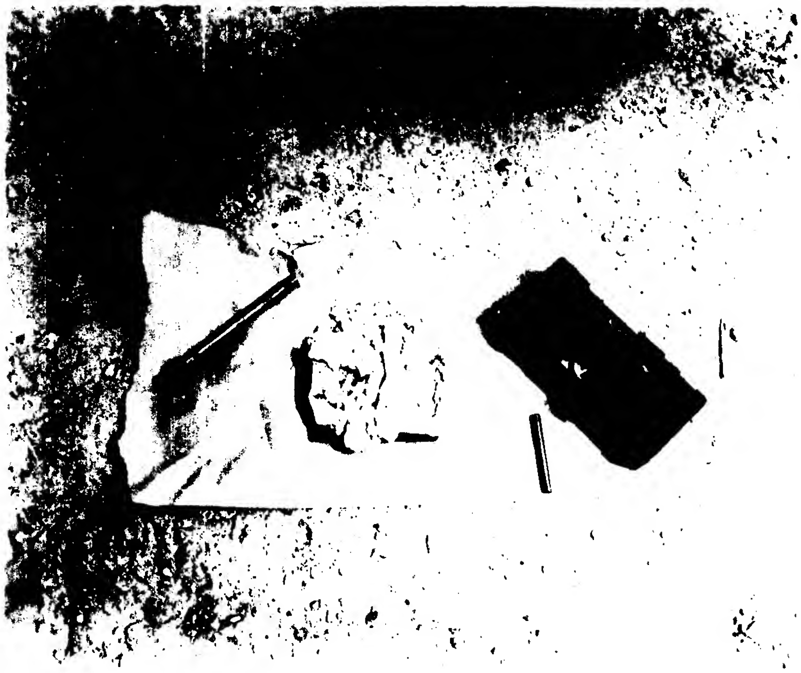

Fig. 24 Parts recovered after a low-order detonation.

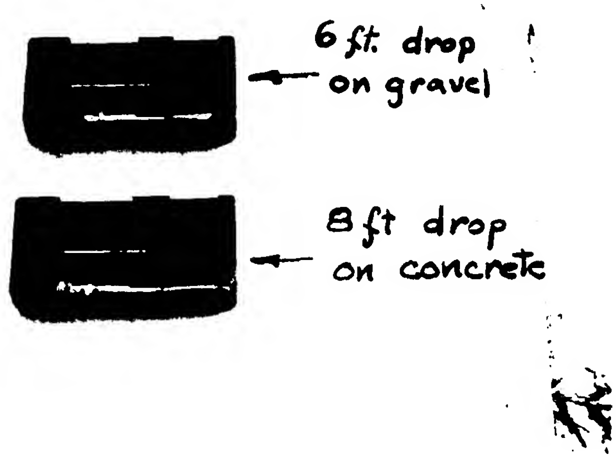

Fig. 25 Results of drop test (Notice crushed delay firing devices)

Part 2. One hundred and five "clams" were tested at 125°F. The delay firing devices were initiated electrically as described in Test 2 of Part III c. All fired high order except for six in which the non-electric caps were not taped in, which was then made standard practice in the electrically initiated tests.

Test 3. Reliability at Low Temperatures

Part 1. The first "clam" was cooled to -35°F and allowed to warm up at room temperature (81°F). The "clam" warmed from -35°F to -30°F in two minutes, and to 0°F in only seven minutes more. A second "clam" was cooled to -32°F and warmed up to -26°F in two minutes, to -22°F in three minutes and to -18°F in a total of four minutes. These observations proved that the "clam" warms very rapidly from -30°F when exposed to room temperature.

Part 2. During the test, the "clams" were cooled to -35°F or below and were prepared for shooting as quickly as possible. As added assurance ten of the "clams" were tested at temperatures from -46°F to -50°F. All eighty-nine "clams" tested in this manner fired high-order except for three in which the delay firing devices failed to function. When the electric cap exploded, the concussion dented the side of the delay firing device and prevented the firing pin from striking the precussion cap. This type of misfire in no way reflects on the "clam" firing train reliability.

Test 4. Holdability

Three positions in which the "clam" held very well were:

1. Bottom of the gas tank
2. On Oil Pan
3. On the side of the engine block.

Three other positions tested and the results were:

1. On top and bottom of differential housing. "clams" fell off with very small amount of shock, not a recommended placement.

2. On top of axle housing. "Clam" fell off only after some very rough bumps.

3. Under hub-cap of pickup. "Clam" remained secure.

The "clams" were also placed on various types of vertical surfaces on the jeep to determine in general where favorable results could be expected.

1. Smooth surfaces; "clam" holds very well.

2. Rough surfaces; "clam" holds poorly, slips, etc., depending on how much area of the magnets is in contact with the metal.

3. Bumpy or Wavey Surfaces; "clam" will not hold if only two magnets are in good contact with the surface.

Test 5. Drop Test

Results of the concrete drop tests showed that a maximum safe drop height for a loaded "clam" was four feet. At six feet the top came loose and the firing device was slightly dented.

When the "clam" was dropped on coarse gravel (approximately 1/2" dia) it was found that a two foot drop was the maximum safe drop height, Fig. 25.

Test 6. Handling at High Temperatures

The test at 120°F showed that C4 could be handled quite effectively. Good compaction can be accomplished and the explosive completely fills all parts of the explosive cavity inside the "clam". At first the C4 stuck to the fingers somewhat, but after the hands began to sweat, as they naturally will when working at 120°F, the sweat kept the C4 from sticking to the fingers. The C4 was quite easy to work with at this temperature and no problems were encountered in loading the "clams".

The average time for loading and arming a "clam" using C4 was two minutes and five seconds. The average time for loading the "clam" with C4 was one minute, for placing the inert caps in position, fifteen seconds, and for placing the delay firing devices, fifteen seconds.

C3 is wrapped in wax paper and packaged in a cardboard box. Difficulty was encountered in removing the card board box and the waxpaper which shredded in small pieces when removed. The C3 was very pliable, but because of the glue-like oil it exudes at high temperatures, it was very messy to handle. When loading the C3 into the "clam" it was difficult to keep from getting it in the groove around the edge where the cover fits into place. Having sweaty hands only seemed to make the C3 more sticky. C3 gives off an obnoxious odor at high temperatures. Since C3 looses very little density when it is worked, it can be loaded a listtle faster than C4 and it is not necessary to use care to assure compaction as with C4. In this test only the time for loading the C3 into the "clams" was recorded, since the time for loading the caps and delay firing devices would be the same as in the previous test. The average time required to load a "clam" with C3 at 120°F was 40 sec. A total of five minutes and five seconds was necessary to load the five clams which included opening the box of C3 and cleaning up the "clams" after replacing the lids.

The C4 handled fairly easily at -30°F and remained pliable enough to be worked, although it was a little rubbery. Pieces of C4 do not stick to each other when being loaded into the "clam", but a good compaction was attainable. The body of the "clam" becomes very stiff at low temperatures

and it was necessary to use the handle of a pocket knife to force the caps down into the cap well resulting in damage to two caps. Two caps were dented while being inserted and one of these had a small chip break off the open end. The same problem was encountered while inserting the delay firing devices, two were damaged to the point that they were probably activated.

Loading the C4 explosive required an average time of two minutes and fifty-one seconds. Placement of the caps required sixty-two seconds per pair, and the delay firing devices required an average of one minute and thirty-eight seconds per pair.

The time required for arming was just about the same when the C3 was used in place of C4 at -30°F. Times required were 1 minute 15 seconds for the caps and 1 minute 18 seconds for the delay firing devices. The retaining fingers designed to hold the delay firing devices in place had been removed from the second "clam" used. This resulted in saving 20 seconds on each firing device placed. The time required to load the C3 was much longer than that when using C4. It took four minutes and fifty-three seconds to load one "clam" with C3. The explosive was so stiff that it was difficult to cut it with a knife. It was necessary to cut it into fairly small chunks before it could be molded in the hands, however once it was worked into a plastic form it was easy to load into the "clam".

Test 8. <u>Reliability at High Temperatures and 100% Humidity</u>

All ten "clams" which were held at 120°F and 100% humidity for sixty-five hours, fired high-order.

Test 9. <u>Reliability After Being Submerged in 6 Inches of Water</u>

One "clam" for 48 hours - did not fire.
Ten "clams" for 24 hours - 6 did not fire.
Ten "clams" for 18 hours - 3 did not fire.
Ten "clams" for 6 hours - all fired.
Ten "clams" for 12 hours - all fired
Ten "clams" for 16 hours - 1 did not fire.
Ten "clams" for 14 hours - 1 did not fire.
Ten "clams" for 12 hours - all fired.

Test 10. <u>Auto Demolition</u>

The engine block shot blew a hole completely through the engine demolishing the third and fourth cylinders. Fig. 26 shows a mans hand seen through the hole blown in the engine. The oil pan shot blew the oil pan off, caused additional cracking to the engine block and appeared to have bent the crank shaft, Fig. 27. The interior shot which was placed under the driver's seat

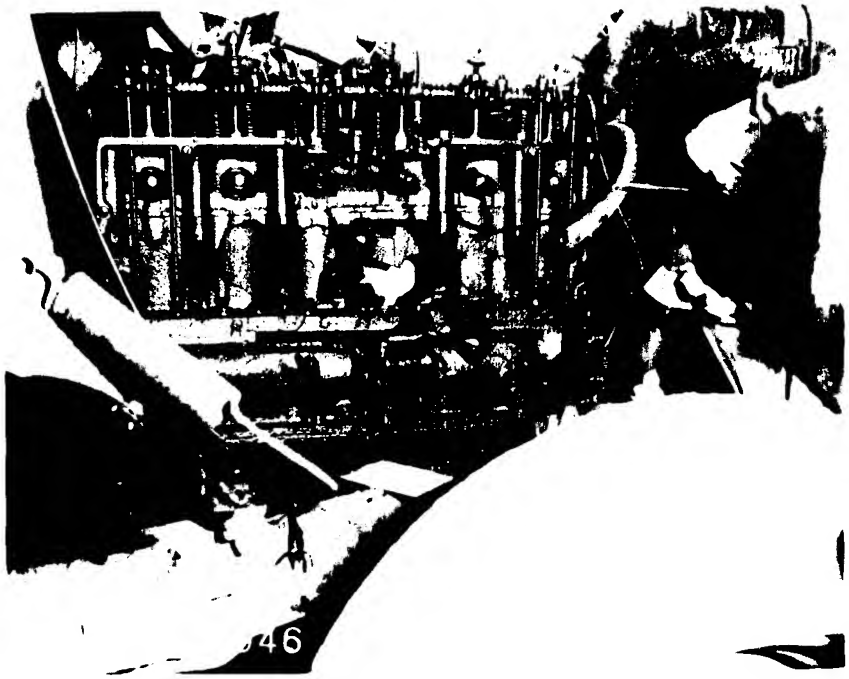

Fig. 26 Results of engine block shot.

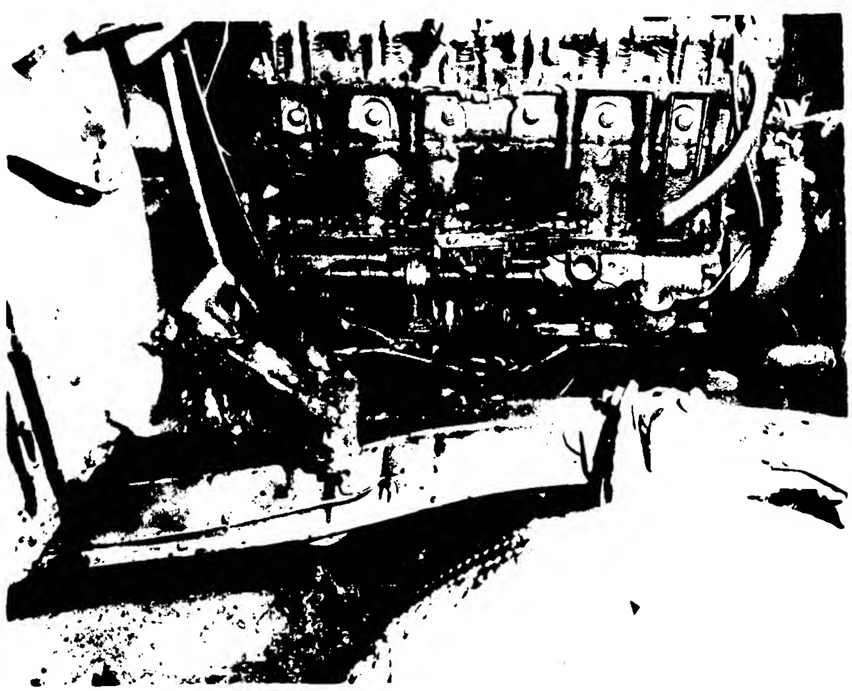

Fig. 27 Results of oil pan shot.

caused complete destruction of the vehicle. This shot resulted in the immediate ignition and vigorous burning of everything combustible inside the car. In addition to the fire it humped up the roof and blew out all the windows, Figs 28 and 29. The fire soon became so hot that it melted off the door handles. The "clam" which was placed under the hub cap of the rear wheel caused destruction of the brake, hub, and wheel and some damage to the axle. The wheel was completely separated from the hub, Fig. 30. The "clam" which was placed on top of the differential housing was successful in blowing a hole in the housing which probably damaged the power train to the rear axle. This same shot ripped the gasoline tank apart and blew a hole in the floor of the car, which probably would have had the same effect as the one under the driver seat. Fig. 31 shows the damage to the differential housing and gas tank as seen through the back seat from inside the car.

Test 10. <u>Steel Penetration</u>

Some difference was noticed between the results of shots made on one foot square plates and the shots made on 3 ft x 3 ft plates. A "clam" will attain about the same degree of penetration in a 3/4" one foot square plate as it will in a 7/8" three ft square plate (compare Fig. 32 with Fig.33.)

The loading density of the explosive also had a large effect on the results. Fig. 34 shows a 1/2" plate that was just dented by a "clam" loaded with a density of 1/20 grams/cc. Fig. 35 shows a 3/4" plate which has been completely cut by a "clam" loaded with a density of 1.58 grams/cc. There was no apparent difference in penetration results between the "clams" tested with the lids on and those with the lids off Figs. 36 and 37.

If a good explosive density is maintained the "clams" will penetrate 7/8" of mild steel with good reliability. The results become somewhat marginal when using less than 200 grams of C4.

Fig. 28 Results of interior shot.

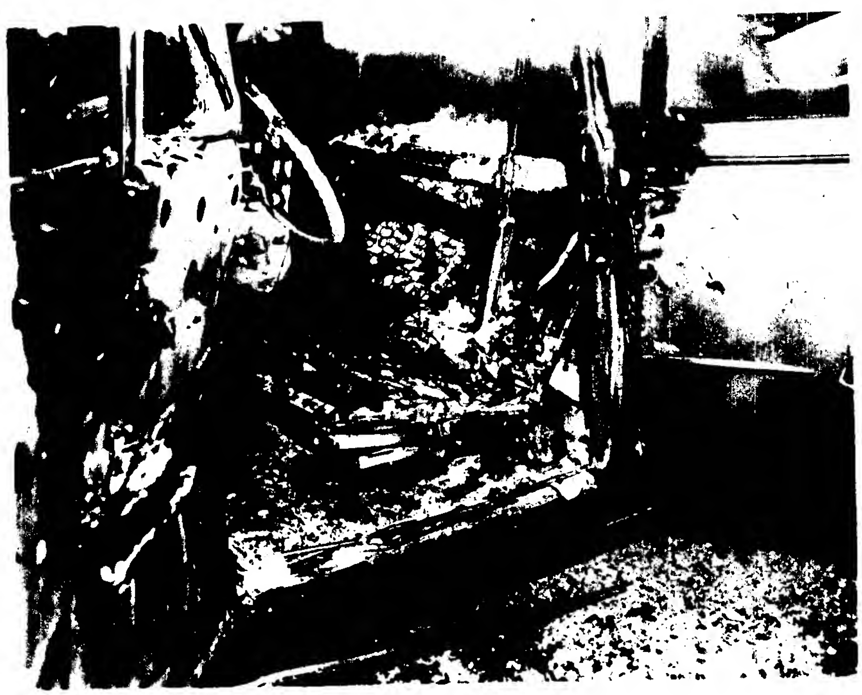

Fig. 29 Results of interior shot.

Fig. 30 Results of under hub cap shot.

Fig. 31 Results of differential shot.

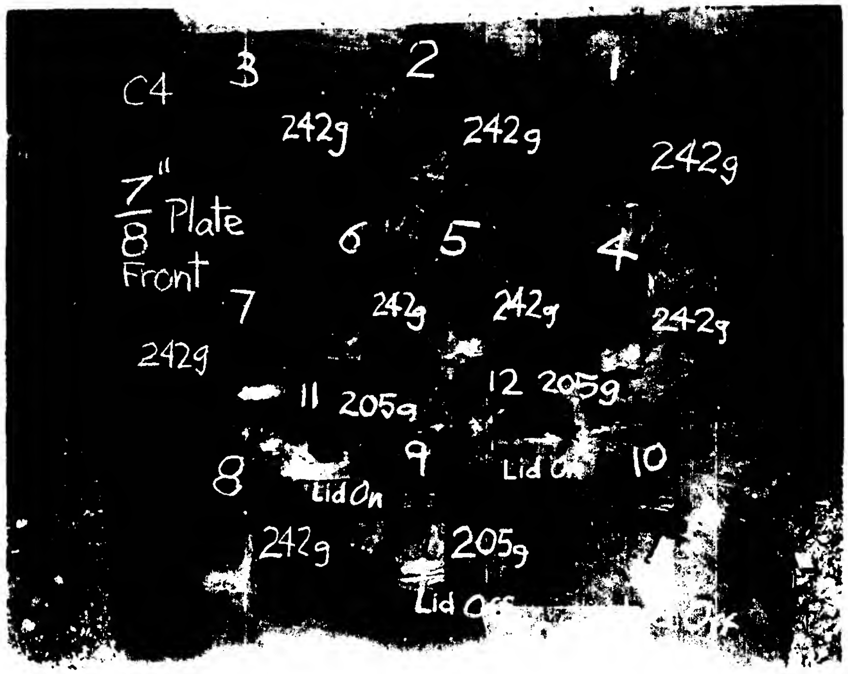

Fig. 32 Average penetration on 3 ft sq piece on 7/8" mild steel plates

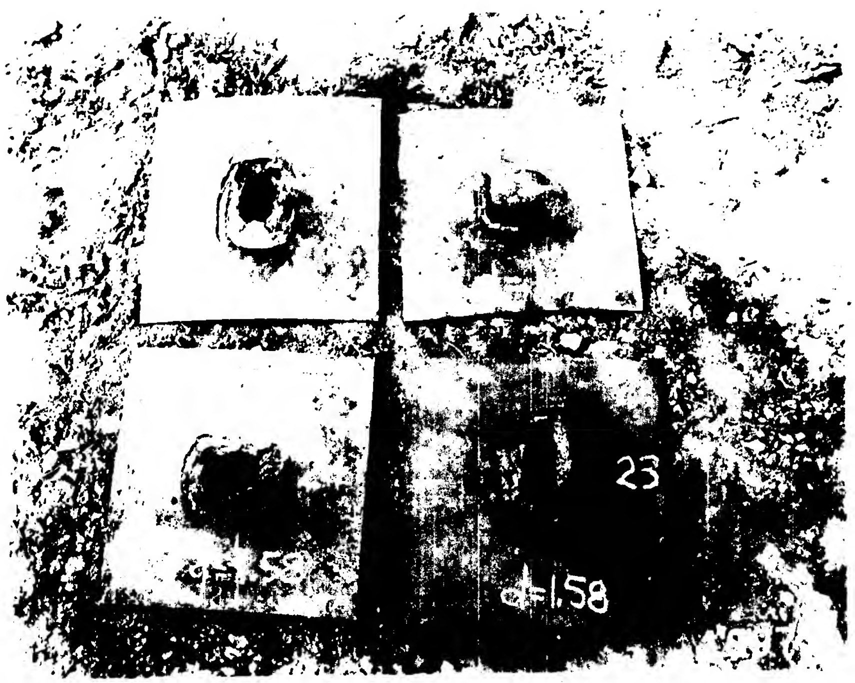

Fig. 33 Average penetration on 1 ft sq 3/4" mild steel plates

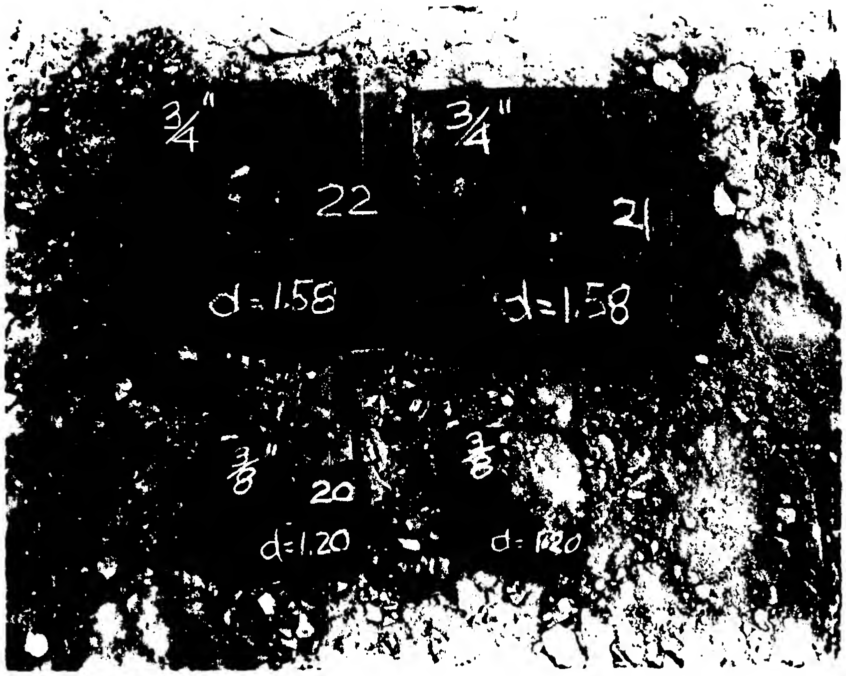

Fig. 34 Good penetration at high density on 3/4" plates (top) and poor penetration at low density on 3/8" plates (bottom)

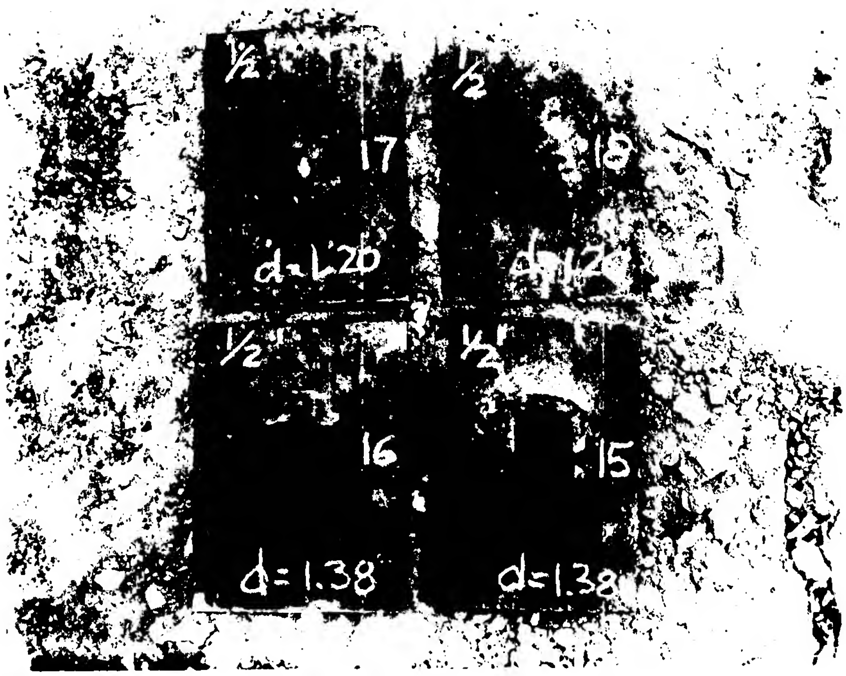

Fig. 35 Poor penetration at low density on 1/2" plates (top) and good penetration at high density 1/2" plates (bottom)

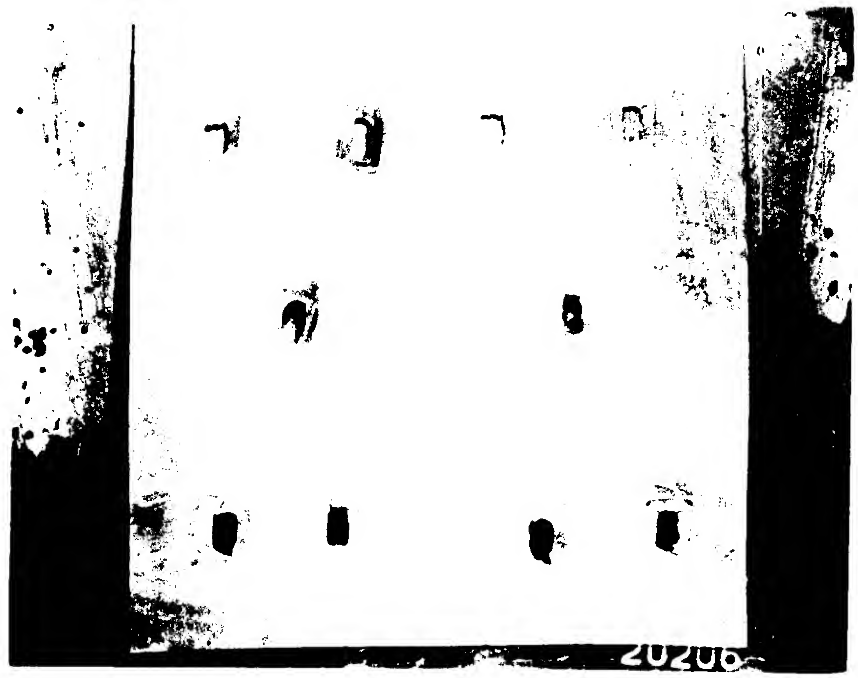

Fig. 36 Comparison of shots with lids on and with lids off.

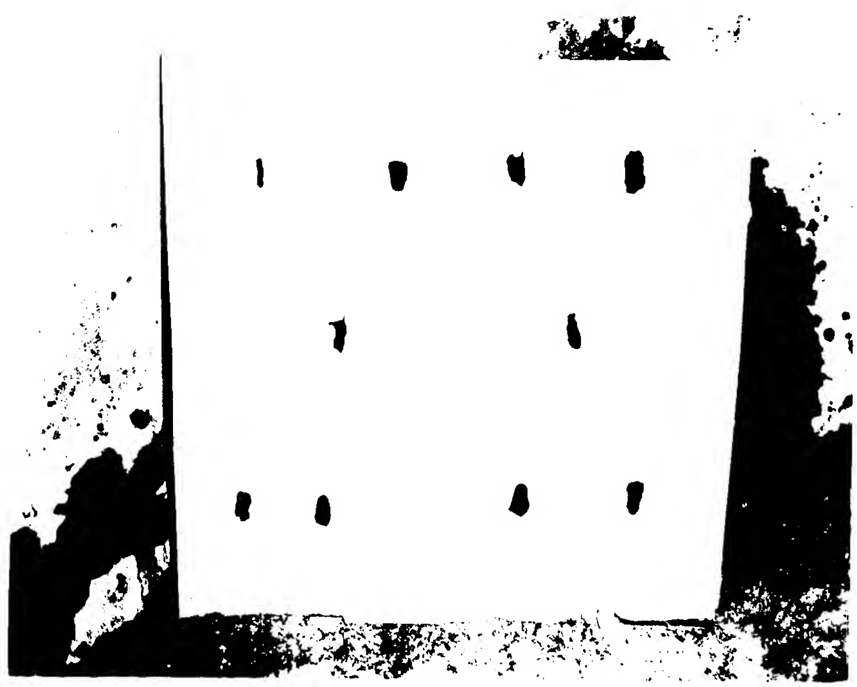

Fig. 37 Comparison of shots with lids on and lids off.

IV DISCUSSION

a. Examination of Methods of Testing and Analysis of Test Results.

(1) Reliability. When it was finally realized how important it was to use two caps in the ambient temperature reliability test, the results were 100% positive high-order detonations. The preliminary tests using one cap and various modifications to the "clam" did, however, give us some interesting and useful information about the marginal reliability of the results obtained throughout the tests. The fact that 20% low-order detonations resulted when using one cap, and that the bottom of the cap well had to be cut out and C4 packed around the cap before 100% reliability was accomplished, seemed to indicate that the use of two caps, with no modification to the cap well, would give us no more than marginal reliability. Another indication of this marginality was the low-order detonation of the two "clams" which were armed with #8 Atlas Caps instead of the Army C of E special caps usually used. The use of two C of E caps, did however, produce surprisingly consistent results. The important thing, after all, is to have 100% reliability, even though the safety factor may be small, and this appears to be the case. High and low temperatures and high humidity did not affect reliability of the "clams", however submersion under 6 inches water for more than 12 hours will cause some failures. The percentage of misfires due to imersion under water increased in a straight line function of the time that the "clams" were under water longer than 12 hours, Fig. 38. The consistent results obtained in the water immersion tests indicated the validity of the 12 hour figure.

Fig. 39 shows a "clam" which was armed to be initiated electrically as described in Test 2 of Part III c. In this test the electric cap dented the side of the delay firing device preventing the firing pin from sliding down and striking the detonator cap. When the detonator cap did not go off the firing train was interrupted and the non-electric caps were not detonated. This gave us an opportunity to determine the extent of the destructive effect the electric cap had on the "clam". The plastic on the corner of the "clam" directly under the cap was blown away and a small portion of the backside of one of the magnets was exposed. The explosive inside the "clam" was not exposed nor disturbed. All-in-all the damage done by the electric cap detonation when taped onto the corner of the "clam" was negligible and it was decided that this practice did not affect the reliability studies of the firing train or the performance of the "dlam" in any way.

(2) Holdability. The holdability test showed that the "clam" can be used on an auto or truck without falling off while traveling at a high speed over very rough terrain, if the "clam" is placed on a suitable surface. The "clam" will hold well on any of the positions used in the auto demolition tests except on top of the differential housing.

(3) Dropability. The drop test was conducted in a manner to simulate the conditions of a loaded and armed "clam" being dropped on two different types of ground. This test was conducted on single units and does not indicate what the safe drop height would be for a crate of "clams"

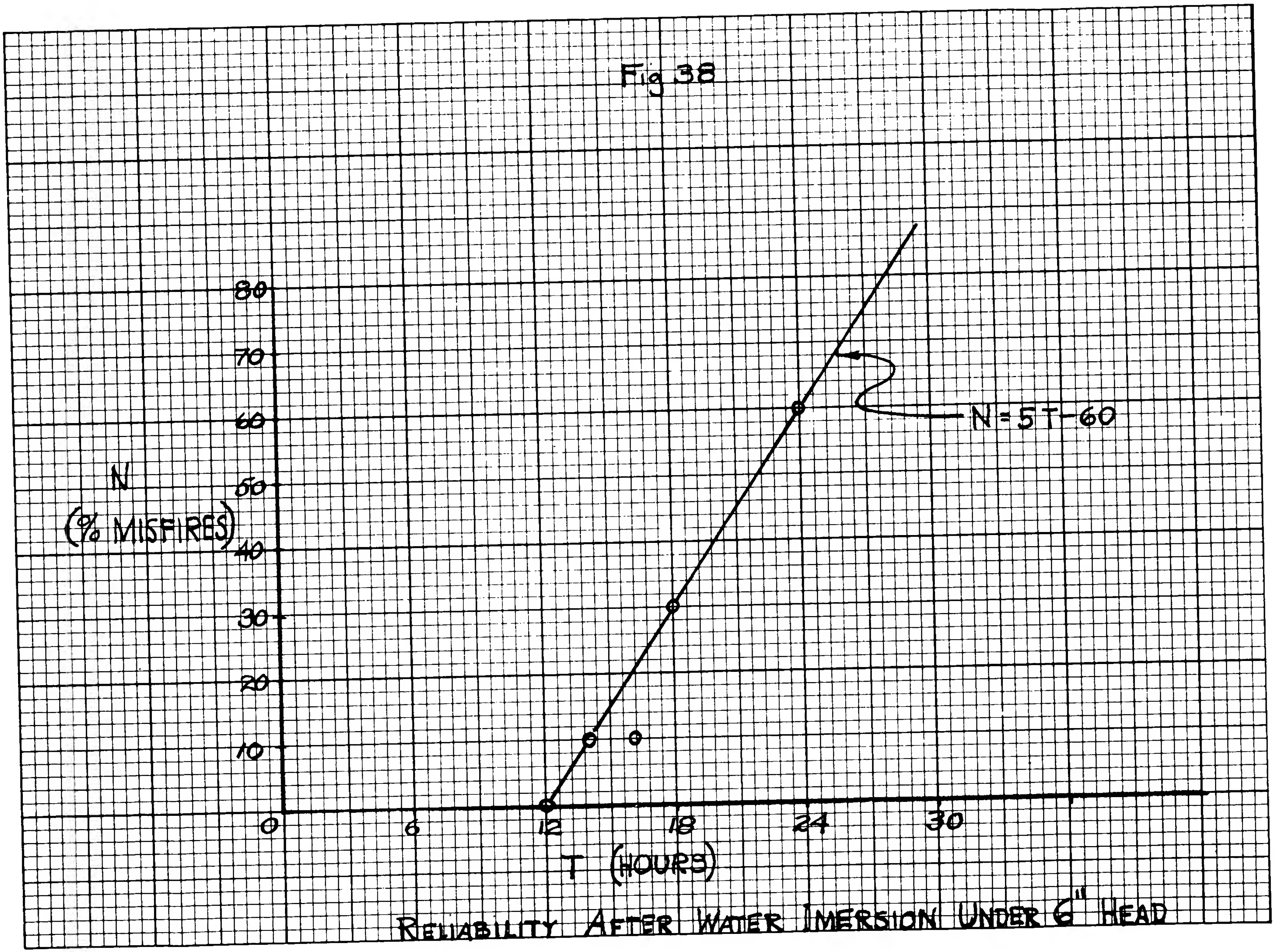

Fig. 38

Declassified in Part - Sanitized Copy Approved for Release 2011/11/08 : CIA-RDP78-03639A001300110001-8

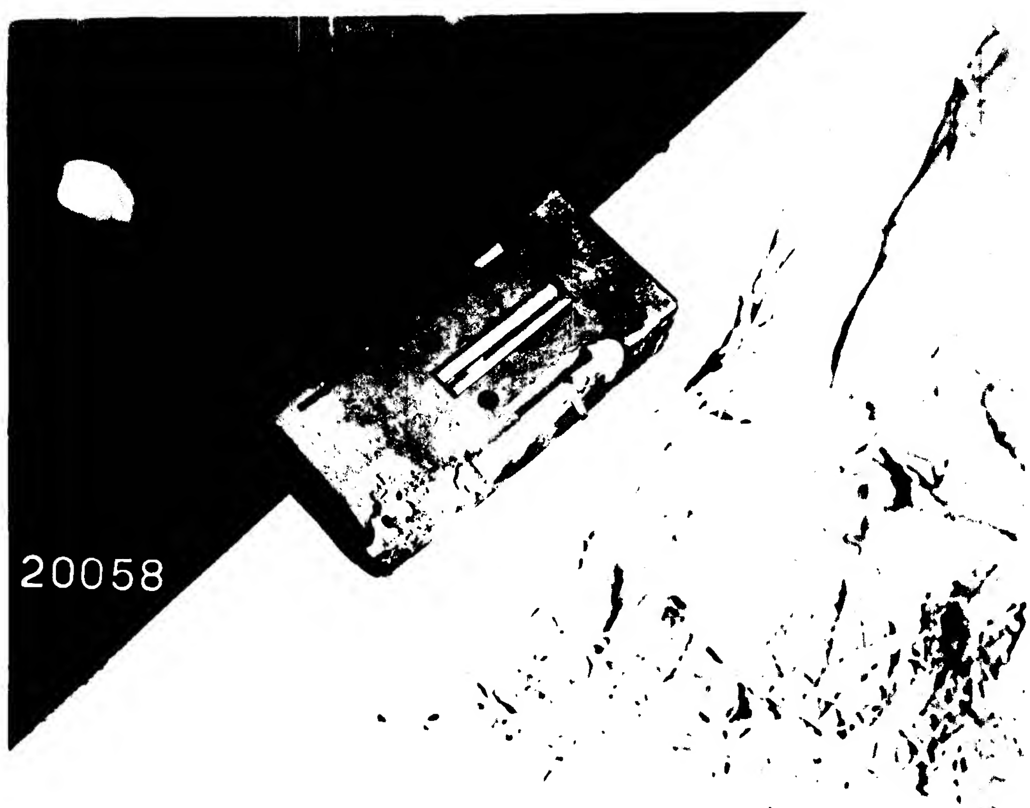

Fig. 39 Results of misfire due to electric initiation.

prepared for shipment. The empty "clams" themselves are quite rugged and will withstand considerable rough treatment without damage. There is little or no danger in dropping "clams" loaded with C4 if they have not been armed with caps and delay firing devices.

(4) Handling. The handling tests showed that at high temperature (120°F) the "clams" can be loaded and armed with C4 in about the same time required for the operation at ambient temperature. At low temperatures however, the loading and arming with C4 takes quite a bit longer. This is due partly to the necessity of wearing cumbersome clothing especially heavy gloves and mittens. Another contributing factor is the tendency of the "clam" to become less plastic even to the point of becoming brittle (at -30°F). This creates a dangerous situation since it is very difficult to arm the cold hardened plastic "clams" without damaging the delay firing devices and caps. The tests showed that the use of C3 in this type of operation has several distinct disadvantages when compared with C4. C3 is wrapped in wax paper and packaged in a cardboard box and at 120°F C3 exudes a sort of sticky oil which runs out the wax paper and tends to glue the cardboard box to the C3.

(5) Auto Demolition. A "clam" can be quickly and easily placed on a vehicle in such a way that it will severely damage a car and kill any occupants, or so that it will cause damage serious enough to require time consuming repairs.

(6) Steel Penetration. The 3 ft x 3 ft mild steel plates used in the steel penetration tests gave more useful information than the one foot square plates. The explosion of a "clam" appears to expend considerable energy on bending the smaller plates. The large plate acts more like a restrained beam which resists the bending force and allows more shear stresses to build up.

b. Evaluation of Equipment. Reliability tests proved that the "clams" 100% reliability was unaffected by heat, intense cold or high humidity. A definite time limit of 12 hours, for immersion under a 6" head of water, was the maximum if 100% reliability is to be retained.

The holdability test indicated that the "clam" will hold to iron or steel under conditions of severe shock if all of the magnets are in contact with the surface. Difficulty was encountered in geting the magnets to maintain good contact on curves and uneven surfaces. The magnets are held to the "clam" by means of springs which allow the magnets an extension of about 1/2" before their holding force is overcome. If the curved surface that the "clam" is being placed on is of such a shape that the springs are under considerable tension, the magnets are less effective and the "clam" is not held firmly in place.

In the penetration test, a "clam" was fired against a curved piece of steel similar in shape to a large steel pipe. The radius on the curve of the plate was so small that the magnets on the clam, when it was placed in a cross-wise position, would not extend easily enough to hold. This would occur also if the "clam" were placed longitudinally on a pipe of

smaller diameter. In order to make the "clam" hold to the curved surface, as shown in Fig. 23, small pieces of wood were inserted under the magnets decreasing the tension on the springs and providing a firmer hold. Weaker springs should allow the "clam" to adhere to this surface without the use of such expedients. It must be remembered that the stronger the springs, the more securely they will hold the "clam" to an even surface. However, it appears that using slightly weaker springs would give better adhesion to uneven surfaces without sacrificing any resistance to shock.

The handling tests pointed out some limiting factors in the use of the "clam", rather than to objectionable features of its design. Most of the objections to design did not cause difficulties until the temperature was so low that the use of the "clam" in general would be impractical. One change suggested during the low temperature handling test was to cut off the firing device retaining fingers on the corners of the "clam" and the same operation could be performed when cold temperatures were anticipated. At -30°F it was very difficult to arm the "clam" without damaging the firing devices unless the retaining fingers were removed, however the retaining fingers did furnish the armed "clam" protection if it were dropped. It is simple enough to cut the retaining fingers off the "clam" if it is to be armed in cold weather, so it seems that leaving the retaining fingers on in the manufacturing process is the best thing to do.

V CONCLUSIONS

The "clam" was tested to determine its limitations and its effectiveness. The only reliability limitation that could be assigned to the "clam" was a twelve hour time limit for immersion under six inches of water. The holdability limitation might be improved somewhat by fitting the "clam" with weaker magnet springs, but on a good, even surface, it is very effective as is. The drop test showed that the loaded and armed "clam" is limited to four feet as a safe drop height. The handling tests indicated a cold temperature working limit of $0^{o}F$. However, this is to a great degree dependent on the skill of the demolition man loading and arming the "clam". The "clam" is inherently limited to $0^{o}F$ when using the chemical delay firing devices. The high temperature handling test pointed out some distinct advantages in the use of C4 instead of C3, however, this is not a limitation.

The auto demolition and steel penetration tests gave us a good indication of the "clam's" effectiveness as a demolition device. Its destructive power and convenient size give it an almost unlimited adaptability.

APPENDICES

TABLE I

FIRING TIME OF DELAY FIRING DEVICE

Temperature Range °F	Time in Minutes (Number of shots tested at each temp range in parenthesis)	
	Black	Red
60 - 65	11.8 (10)	26.9 (10)
65 - 70	9.3 (12)	19.3 (4)
70 - 75	9.0 (24)	-- (None)
75 - 80	8.4 (38)	-- (None)
80 - 85	7.6 (51)	20. (3)
85 - 90	7. (49)	14.9 (8)
90 - 95	6.7 (57)	13. (20) "8-18"
95 - 100	6.7 (44)	13. (19)
100 - 105	5.2 (39)	10.8 (19)

TEST PLAN

EVALUATION TESTS OF THE CLAM

I. Purpose:

This test plan is to provide the procedures for tests to be conducted on a "clam" explosive container to determine its effectiveness and adaptability when employed under a wide variety of conditions.

II. Objective of Tests:

The objective of these tests will be to evaluate the "clam" design from the standpoints of functional performance, reliability of firing train, dropability, handling, and storage.

III. Test Procedures:

Test 1: Penetration

a. Three "clams" will be tested in each penetration test.

(1) On steel plates of varying thicknesses from ¼ in. at ¼ in. increments, i.e., ¼ in., ½ in., 3/4 in. to failure.

(2) Cast iron tests. (Scrap engine block, CI plate, etc.)

b. Position tests to determine effectiveness of penetration in various positions (with detonator on top, etc.)

Test 2: Rate of detonation, ten tests per series.

a. Compare rate using one cap as against dual initiation.

b. Compare rates at three densities or degree of compaction.

Test 3: Dropability.

a. Test 10 "clams" with inert caps and C4 simulant at heights up to 10 ft.

(1) Check to see whether lids are secure.

(2) Check for damage to "clam".

(3) Check delay firing devices for damage or activation.

Test 4: Holding or adhering qualities.

a. Tests will be conducted with inert caps and explosive simulant.

b. Test on trucks and jeep over rough roads.

(1) Place on bottom of gas tank.

(2) Place on engine block.

(3) Place on oil pan.

(4) Place on uneven surfaces of other vantage points.

Test 5: Handling at various temperatures. Each test will be run at -30°F, 70°F and 120°F, 10 "clams" for each temperature range.

a. Studies on ease of handling and time for loading "clams" with (C3 and C4)

b. Time studies on handling "clams" (i.e., closing, placing caps, and delay firing devices).

Test 6: Reliability of Firing Train under various conditions.

a. Test 100 units at -30°F.

b. Test 300 units at 70°F.

c. Test 100 units at 120°F.

(1) Underwater test 10 units 70°F, 48 hours - 6 inch water.

(2) Underwater test 10 units 70°F, 48 hours - 12 inches water.

(3) Continue underwater tests increasing depth by 6 inch increments until unit fails.

d. Humidity test 10 units at 120°F, 90% humidity - 48 hours. Then test fire.

IV. Equipment to be obtained for the tests.

a. 1000 "clam" containers

b. 700 non-electric blasting caps. *

* on hand

c. 800 M1 delay firing devices. **

d. 200 lbs C4, (bulk) *

e. 20 lbs C4 simulant, (inert) *

f. 50 inert blasting caps *

g. Steel plate, $\frac{1}{4}$ in, $\frac{1}{2}$ in. 3/4 in. and 1 in. in thickness. *

h. 3 each salvage auto or truck engine blocks. ***

* On hand

** On order, estimated delivery date 20 days

*** Obtainable from salvage on short notice.

File: Final Report
Explosive Clam

AUTO DEMOLITION SUPPLEMENT

(See Test 10 Page 16)

Procedure. Results obtained in a previous test when the "clam" was placed on the floor under the driver's seat of the vehicle were so favorable and far beyond any predictions (pages 26 and 28), it was decided to repeat the test for verification. A second salvage vehicle, six cylinder, four door Chevrolet sedan (Fig. 40) was obtained and moved to the demolition range, Engineer Proving Ground. The "clam" was placed under the driver's seat on the floor as in the previous test, and initiated electrically.

Results. The blast from detonation of the explosive blew out a loose glass in the rear of the vehicle and the fireball filled the interior. Within a short period, five to ten seconds, the entire interior burst into flame and burned very rapidly (Fig. 41). The fire extended to the rear and soon involved the gasolene tank (Fig. 42) and eventually the entire vehicle.

Discussion. The sequence of events and results following detonation of the "clam" were very similar to those observed in the first test and can be assumed to be the normal pattern. Any occupants of the vehicle would be killed or severely shocked and would not be able to take any action to extinguish the fire in its early stages. So much of the vehicle is involved within a few seconds after the explosion that first aid firing fighting equipment would be ineffective. By the time fire fighting equipment would arrive on the scene the vehicle would probably be destroyed.

Conclusions. When the "clam" is detonated within the passenger area of a vehicle it will probably be heavily involved by fire within a few seconds resulting in total destruction.

Fig. 40. Vehicle before demolition.

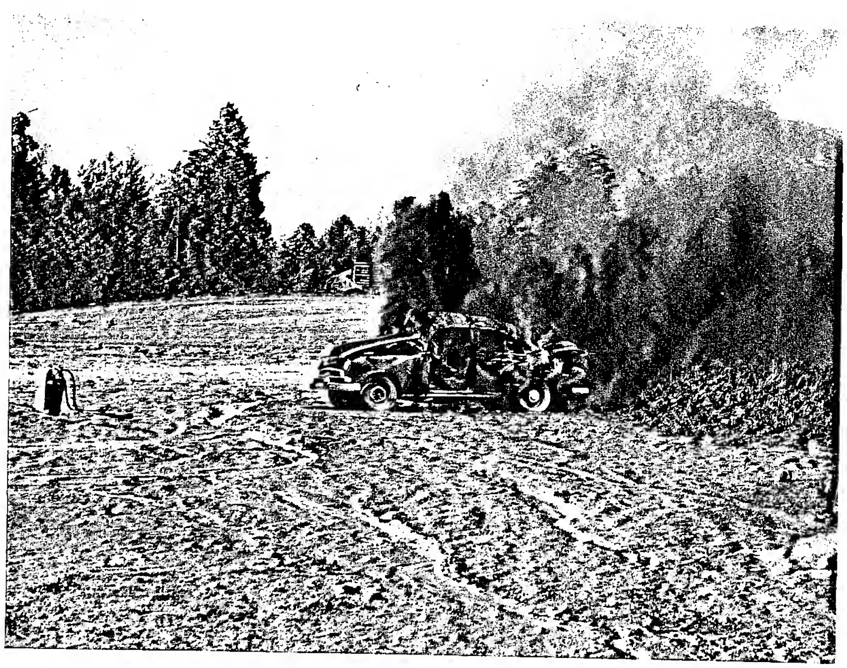

Fig. 41. Results of explosion and progress of fire soon after detonation.

Fig. 42. Several minutes after detonation gasolene tank now burning.

Declassified in Part - Sanitized Copy Approved for Release 2011/11/08 : CIA-RDP78-03639A001300110001-8